Aggregate Bank Capital and Credit Dynamics

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The views expressed in this paper are those of the authors and do not necessarily represent those of the IMF or IMF policy.
Financial regulators and central banks now control powerful macro-prudential tools for promoting systemic stability.

Long-term impact on growth and financial stability?

DSGE models cannot really help: they were designed to reproduce short-term reactions of prices and output to monetary policy decisions.

To study the long-term impact of macro-prudential policies on growth and financial stability, one needs a different type of model.

We provide an example of such a model.
OUR CONTRIBUTION

▶ General equilibrium dynamic model with financial frictions, in the spirit of Brunnermeier-Sannikov (2014) and He-Krishnamurthy (2013).

▶ Banks are explicitly modeled.

▶ Bank capital serves as a loss-absorbing buffer and determines the volume of lending.

▶ Model allows the analysis of the long-run effects of minimum capital requirements on lending and systemic stability.

▶ Main implications are in line with empirical evidence.
RELATED LITERATURE

1. Macro-finance in continuous time

2. Welfare impact of capital requirements
   ▶ Martinez-Miera and Suarez (2014)
   ▶ DeNicolò-Gamba-Lucchetta (2014)
   ▶ Nguyen (2014)
   ▶ Begenau (2015)
ROADMAP

1. Model
2. Competitive equilibrium
3. Long run dynamics
4. Credit market failure
5. Application to macro prudential policy analysis
MODEL

- General equilibrium model: real sector and banking sector.
- One physical good, can be consumed or invested.
- Households invest their savings in bank deposits and bank equity.
- Banks invest in (risky) loans to entrepreneurs and reserves (can be <0).
- **Equity** acts as a buffer to guarantee safety of deposits (no deposit insurance) and interbank borrowings.
- Entrepreneurs have no capital and must borrow from banks, who monitor them: no direct finance.
GLOBAL PICTURE
MODEL

- Households and entrepreneurs are risk neutral and discount future consumption at rate $\rho$.

- Interbank rate $r$ is fixed and less than $\rho$.

- Households receive interest $r_D$ on deposits. At equilibrium $r_D = r$.

- Households derive utility from holding riskless deposits (*transactional demand for safe assets* as in Stein (2012)).

- Supply of deposits is fixed and is a decreasing function of $(\rho - r)$.

- For simplicity, $r \equiv 0$ (all qualitative results hold when $r > 0$).
MODEL

Firms:

- can borrow 1 unit of productive capital from banks at time $t$, must repay $1 + R_t h$ at $t + h$

- if borrow, produce $x h$ unit of good, where $x$ is distributed over $[0, \bar{R}]$ with density $f(x)$

- borrow when $x > R_t$; aggregate demand for loans is a decreasing function of loan rate $R$

\[
L(R) = \int_{R}^{\bar{R}} f(x) dx
\]

- productive capital is destroyed (default) with probability

\[
pdt + \sigma_0 dZ_t,
\]

where $\{Z_t, t \geq 0\}$ is a standard Brownian motion (aggregate shocks)
**MODEL**

- Aggregate shocks in the real sector translate into banks’ profits/losses

- Book equity of an individual bank evolves:

  \[
  de_t = k_t [(R_t - p)dt - \sigma_0 dZ_t] - d\delta_t + di_t,
  \]
  
  where \( k_t \) is the volume of lending to firms at time \( t \)

- **Aggregate** bank equity evolves:

  \[
  dE_t = K_t [(R_t - p)dt - \sigma_0 dZ_t] - d\Delta_t + dI_t,
  \]
  
  where \( K_t \) is aggregate lending

- **Main friction**: issuing new equity entails proportional cost \( \gamma \)

- **Markovian competitive equilibrium**: \( R_t = R(E_t) \) and \( K(E_t) = L(R(E_t)) \)
AN INDIVIDUAL BANK’S PROBLEM

- An individual bank chooses lending, dividend and recapitalization policies to maximize shareholder value:

\[ v(e_t, E_t) = \max_{k_s, d\delta_s, d\delta_i} \mathbb{E}\left[ \int_t^{+\infty} e^{-\rho(s-t)}(d\delta_s - (1 + \gamma)d\delta_i) \right] \]

- Shareholder value is linear in \( e \):

\[ v(e, E) \equiv eu(E), \]

where \( u(E) \) is the Market-to-Book ratio.

- Only aggregate capital \( E \) matters for banks’ policies.
Dividend and recapitalization policies of a “barrier” type:

- banks distribute dividends when $E_t = E_{max}$, such that $u(E_{max}) = 1$;
- banks recapitalize when $E_t = E_{min} = 0$
EQUILIBRIUM LOAN RATE

- Positive loan spread:

\[ R(E) - p = \sigma_0^2 K(E) \left[ - \frac{u'(E)}{u(E)} \right], \quad \text{where} \quad u'(E) < 0 \]

“lending premium”

- Source of lending premium: implied risk-aversion of bankers with respect to variations in aggregate capital

- \( u(.) \) is a discounted martingale:

\[ \rho u(E) = L(R)(R(E) - p)u'(E) + \frac{\sigma_0^2 L^2(R)}{2} u''(E) \]

- From these two equations we deduce

\[ R'(E) = - \frac{1}{H[R(E)]}, \quad \text{where} \quad H(R) = \frac{\sigma_0^2[L(R) - (R - p)L'(R)]}{2\rho \sigma_0^2 + (R - p)^2} \]
**EQUILIBRIUM LOAN RATE AND MTB RATIO**

The diagram illustrates the relationship between the loan rate $R(E)$ and the MTB ratio $u(E)$ as a function of the equity $E$.

For the loan rate $R(E)$:
- $R_{\text{max}}$ is the maximum loan rate.
- $R(E)$ decreases as $E$ increases from $E_{\text{min}} = 0$ to $E_{\text{max}}$.

For the MTB ratio $u(E)$:
- $1 + \gamma$ is the upper bound of the MTB ratio.
- $u(E)$ decreases as $E$ increases from $E_{\text{min}} = 0$ to $E_{\text{max}}$.

The points $E_{\text{min}} = 0$ and $E_{\text{max}}$ define the range of the equity $E$. The graph visually represents how the loan rate and MTB ratio change with respect to equity.
COMPETITIVE EQUILIBRIUM (CE)

- Aggregate bank capital evolves according to:

\[ dE_t = L(R(E_t)) \left[ (R(E_t) - p)dt - \sigma_0 dZ_t \right] \]

- The loan rate function \( R(E) : [0, E_{max}] \rightarrow [p, R_{max}] \) is implicitly given by

\[
E = \int_{R(E)}^{R_{max}} H(s) ds, \quad \text{where} \quad H(s) = \frac{\sigma_0^2 [L(s) - (s - p)L'(s)]}{2\rho\sigma_0^2 + (s - p)^2}
\]

- \( R_{max} \) and \( E_{max} \) increase with financing friction \( \gamma \)

- Testable predictions: equilibrium loan rate and market-to-book ratio are decreasing functions of aggregate capital
LOAN RATE DYNAMICS

► Loan rate $R_t = R(E_t)$ has explicit dynamics

\[ dR_t = \mu(R_t)dt + \sigma(R_t)dZ_t, \quad p \leq R_t \leq R_{\text{max}}, \]

with

\[ \sigma(R) = \frac{2\rho\sigma_0^2 + (R - p)^2}{\sigma_0 \left(1 - (R - p)\frac{L'(R)}{L(R)}\right)} \quad \text{and} \quad \mu(R) = \sigma(R)h(R), \]

where $h(.)$ is explicit.
**NUMERICAL EXAMPLE**

Particular specification of the demand for loans (max. lending $\equiv 1$):

$$L(R) = \left( \frac{\bar{R} - R}{\bar{R} - p} \right)^\beta$$

where $\beta > 0$, $\bar{R} > p$

**Remark:** $\mu(R)$ is very small compared to $\sigma(R)$. Linearization around the (stable) DSS can be very misleading!
LONG RUN BEHAVIOR OF THE ECONOMY

- Full description of long run behavior of the economy: stochastic steady state.
- We can compute the ergodic density function of \( R \) (or \( E \)):

\[
\frac{g'(R)}{g(R)} = \frac{2\mu(R)}{\sigma^2(R)} - \frac{2\sigma'(R)}{\sigma(R)}, \text{ on } [p, R_{max}]
\]

Remark: the long run behavior of the economy is driven by the endogenous volatility.
CE IS NOT CONSTRAINED EFFICIENT

- Banks do not internalize the impact of their lending decisions on the dynamics of $E$ (i.e., endogenous volatility and expected profits).

- Compared to Second Best (SB), banks lend too much (overexposed to aggregate risk) when $E$ is low and too little when $E$ is high.
APPLICATION: MINIMUM CAPITAL RATIO

- What happens if banks are subject to a minimal Capital Ratio (CR) $\Lambda$?

$$e_t \geq \Lambda k_t$$

- Maximization problem of an individual bank:

$$v_\Lambda(e, E) = \max_{k_t \leq \frac{e}{\Lambda}, d\delta_t, dt} \mathbb{E} \left[ \int_0^{+\infty} e^{-\rho t} (d\delta_t - (1 + \gamma)dt) \right]$$

- Homogeneity property is preserved:

$$v_\Lambda(e, E) \equiv eu_\Lambda(E)$$

- We find that CR constraint binds for low $E$ and is slack for high $E$.

- $u_\Lambda(.)$ and equilibrium loan rate $R_\Lambda(.)$ have different expressions in constrained ($E < E_c^\Lambda$) and unconstrained ($E \geq E_c^\Lambda$) regions.
Banks increase their target level of capital \((E^\Lambda_{\text{max}} > E_{\text{max}})\) and recapitalize earlier \((E^\Lambda_{\text{min}} > 0)\).

- Small and moderate \(\Lambda\): both the unconstrained and constrained regimes co-exist.
- Very high \(\Lambda\): the unconstrained region disappears (no extra capital cushions).
Banks reduce lending not only in the constrained region, but also in the unconstrained one.

Moderate capital requirements can bring lending closer to the SB level in the states with low capitalization.

Very high capital requirements induce a severe reduction in lending in all states.
**Capital ratio and financial (in)stability**

- Capital requirements affect the probabilistic behavior of the system.
- Under low capital requirements, the ergodic density of $E$ is concentrated in low capitalized states.
CAPITAL RATIO AND FINANCIAL (IN)STABILITY

- **Stability measure**: $T_\gamma(\bar{E})$ - the average time to recapitalization starting from the average level of aggregate capital $\bar{E}$.

- For low $\Lambda$, the system becomes even *less stable than in the absence of regulation*.

- For very high $\Lambda$, the system is more stable than in the Second Best.
CONCLUSION

▶ Tractable dynamic macro model where aggregate bank capital drives credit volume.

▶ Asymptotic behavior described by ergodic distribution (stochastic steady state).

▶ Model shows that pecuniary externalities in credit markets can arise even in the absence of fire-sales.

▶ Model permits simple analysis of macro-prudential policy.

▶ Further investigations:
  ▶ interaction between macro-prudential and monetary policies
  ▶ market financing complementary to bank financing
Thank you!
EMPIRICAL EVIDENCE: DATA DESCRIPTION

- Panel of publicly traded banks in 43 advanced and emerging market economies (1992-2012):
  - **U.S. banks**: 728 banks
  - **Japan**: 128 banks
  - **Banks in advanced economies**: 248 banks
  - **Banks in emerging market economies**: 183 banks

<table>
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<th>Identifier</th>
<th>Variable</th>
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<td>ret</td>
<td>bank gross return on assets</td>
<td>total interest income/earning assets</td>
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<td>mtb</td>
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<tr>
<td>TBE</td>
<td>total bank equity</td>
<td>sum of bequity</td>
</tr>
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</table>
Empirical evidence: Conditional Correlations

**Predictions:** Loan rate and MTB ratio are decreasing functions of aggregate bank capital

\[ Y_{it} = \alpha + \beta E_{t-1} + \gamma_1 \text{bequity}_{it-1} + \ldots + \gamma_5 \text{Timedummy}_{it} + \epsilon_{it} \]

\[ < 0 \]